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6. AUTHOR(S)

Dr T. N. Krishnamurti

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Department of Meteorology, B-161
Florida State University
Tallahassee FL 32306

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AFOSR/NL
Building 410
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13. ABSTRACT (Maximum 200 words)

Currently in numerical weather prediction, two avenues for cloud forecasting are being pursued by the research community. The conventional one defines cloud coverage as a function of prevailing relative humidity. The new method explicitly predicts clouds as a variable of the model. Our research effort covers both avenues. The major results of our research are: (a) The threshold relative humidity approach exhibits a decay of cloud fractions during the medium range weather forecasts. The major errors in the prediction appear to occur in the first 24 hours, an initialization problem. Observed clouds appear to exhibit more of a resilience than is demonstrated by the models. Long lasting cloud debris (i.e., non precipitating elements) are not reasonably handled by the model. This deficiency is related to the strong selection rules imposed by the model for the existence of clouds; (b) The explicit treatment of clouds where the cloud water mixing ratio is used as a dependent variable of the model, appears to handle long lasting clouds in a more realistic manner. It does not show the rapid spin-down feature present in the threshold relative humidity approach; and (c) A large effort on physical initialization is currently underway in our global modeling effort. This provides a consistent analysis of the humidity variable with respect to the rain rates (as seen from satellite based measurements).

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P.I.:	T.N. Krishnamurti
Address:	Department of Meteorology, B-161 Florida State University Tallahassee, FL 32306

Summary of Important Research Advances

Currently in numerical weather prediction, two avenues for cloud forecasting are being pursued by the research community. The conventional one defines cloud coverage as a function of prevailing relative humidity. The new method explicitly predicts clouds as a variable of the model. Our research effort covers both avenues.

The major results of our research are:

a) The threshold relative humidity approach exhibits a decay of cloud fractions during the medium range weather forecasts. The major errors in the prediction appear to occur in the first 24 hours, an initialization problem. Observed clouds appear to exhibit more of a resilience than is demonstrated by the models. Long lasting cloud debris (i.e. non precipitating elements) are not reasonably handled by the model. This deficiency is related to the strong selection rules imposed by the model for the existence of clouds.

b) The explicit treatment of clouds where the cloud water mixing ratio is used as a dependent variable of the model, appears to handle long lasting clouds in a more realistic manner. It does not show the rapid spin - down feature present in the threshold relative humidity approach.

c) A large effort on physical initialization is currently underway in our global modelling effort. This provides a consistent analysis of the humidity variable with respect to the rain rates (as seen from satellite based measurements).

The physical initialization follows our recent work, Krishnamurti et al. (1991). This entails several steps:

i) Preparation of rainfall totals based on OLR, SSM/I and rain gauge data sets during a 24 hour period prior to the start of the forecast.

ii) Calculations of surface flux of moisture from the difference between the vertically integrated apparent moisture sink (Q2 following Yanai et al., 1973) and the rainfall rates.

iii) Use of a reverse similarity theory to obtain the humidity variable on top of the constant flux layer consistent with the moisture fluxes.

iv) Vertical restructuring of the moisture variable consistent with the observed rain rates using a reverse cumulus parameterization algorithm.

v) A further restructuring of the moisture variable in the upper troposphere using a bisection method that minimizes the difference between the 'satellite based' and the 'model based' outgoing longwave radiations.

vi) A newtonian relaxation phase between hour -24 to hour 0 of forecast where the model is spun up to accept, as closely as possible, the observed rain rates and the modified humidity field. During this step the vorticity, divergence and surface pressure fields are nudged to their pre-assigned values at hour 0. For this the equation for dynamic relaxation takes the form

$$\frac{\partial A^m_l}{\partial t} = N\,(A^{om}_l - A^m_l) \qquad (1)$$

Its finite difference approximation may be written as:

$$\frac{A^m_l\,(t+\Delta t) - A^{*m}_l\,(t+\Delta t)}{2\Delta t} = N\,(A^{om}_l(t+\Delta t) - A^m_l(t+\Delta t)) \qquad (2)$$

or

$$A_l^m (t + \Delta t) = (A_l^{*m}(t + \Delta t) + 2N\,\Delta t\, A_l^m (t + \Delta t))/(1 + 2\,N\Delta t) \quad (3)$$

Here $A_l^{*m}(t + \Delta t)$ is a predicted value of A_l^m at time $(t + \Delta t)$ prior to Newtonian relaxation, and $A_l^m(t + \Delta t)$ is its final value achieved after relaxation. It may be noted that the relaxed value is the weighted average of model predicted value and observed value, with weights depending upon nudging coefficient N. For the nudging of vorticity field we used a nudging coefficient of 1.0×10^{-4}, whereas divergence and surface pressure fields were nudged using a weaker coefficient of 0.5×10^{-4}. With this the diabatic heating and the divergence field are allowed to undergo a spin up while essentially retaining the rotational part of the motion field.

The theoretical framework for the physical initialization is presented in detail in Krishnamurti et al. (1991).

The current thrust, during this last year of this 3 year project, is on evaluation of the proposed methodologies. We are carrying out a large array of inter-comparison experiments in order to assess the relative merits of the threshold versus explicit clouds - with or without the physical initialization.

REFERENCES

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